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Vulnerability of catfish to fishing: an investigation based on the landings at Mumbai

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ABSTRACT

The estimated annual average catch and catch rate of catfish by trawlers at New Ferry Wharf, Mumbai decreased from 2,586 t and 2.2 kg/h during 1991-1994 to 1,548 t and 1.0 kg/h during 1995-2004. *Tachysurus tenuispinis*, *T. serratus* and *T. thalassinus* appear to be susceptible to fishing. *T. thalassinus* grow slowly, attain large size, mature late, get recruited early to the fishery, and a large majority are exploited before attaining first maturity. The sex ratio of five species of catfish was biased toward male when young, but the number of males substantially decreased in larger group, and at lengths closer to L_{max}, males were rarely found. The presence of immature and mature ova in the same ovaries indicated that they are fractional spawners. The number of ripe eggs in the oro-buccal cavity of gestating males was always less than the number of eggs recorded in the ovary of females. Due to gestation behaviour, the males are more vulnerable to fishing.

Introduction

The marine catfish landings along the Indian coast declined from 67,666 t in 1982 to 45,335 t in 2005 (Menon *et al.,* 2000; CMFRI, 2006), and the contribution of catfish to the demersal landings from 24.6% in 1970 to 8.0% in 2005. Twenty years back most of the commercially important species of marine catfish, except *Osteogenieosus militaris* were under heavy fishing pressure (CMFRI, 1987). Since then, the effect of fishing on catfish stocks has become the focus of major concern. The shoreward breeding migration, low fecundity, oral incubation and incessant bottom trawling which affect the habitat and reduce the prey abundance, are attributed as the reasons for the decline in catfish landings (Menon, 2004). Studies by Sastry and Kasim (1989) and Chakraborty *et al.* (1997) have indicated fishery-induced depletion of catfish stocks along Maharashtra coast. This paper presents the results of investigations on the catfish fishery off Mumbai and an attempt has been made to show how some disadvantageous biological characteristics induce vulnerability of catfish populations to fishing.

Materials and methods

The study was based on weekly observations on the commercial trawl landings during 1997-2002 at New Ferry Wharf, Mumbai. On the days of observation, 10 to 20% of multiday trawlers that landed the catch were selected randomly and the catfish and total catch were recorded in addition to fishing effort (trawling hours). The data were raised to the day and subsequently to the month and year. Samples of important species, namely *Tachysurus tenuispinis, T. thalassinus, T. caelatus, T. jella* and *O. militaris* were collected on the observation days and analyzed for sex, length, fecundity and ova diameter. Males with incubating eggs in the mouth were analyzed for the number of eggs and feeding condition. The diameter of mature ova were measured by means of a vernier caliper and small ova with ocular micrometer. The length at first maturity was determined by considering the ovary in stage III and above as mature. The von Bertalanffy growth parameters, K and Lα for *T. thalassinus*, *T. caelatus*, and *O. militaris* off Mumbai were taken from Chakraborty *et al.* (1997) and those of *T. jella* from Raje *et al.* (unpublished).

Results and discussion

Fishery

The fishing effort of trawlers based at New Ferry Wharf increased from 1.0 million hours (m h) in 1991 to 1.7 m h in 2004. During this period, the catfish landings decreased from 2,610 t to 1,727 t (Fig.1). Based on the catch and catch rate, the 14 year period could be divided into two blocks. In the first four years between 1991 and 1994, the average catch and catch rate were high at 2,586 t and 2.2 kg/h respectively. In the next ten years, the average catch and catch rate decreased to 1548 t and 1.0 kg/h, *i.e.,* the catch and the catch rate decreased by 40% and 55%, respectively. The catch rate showed a linear decrease with increasing effort in 14 years (Fig. 2). The contribution of catfish to the total trawl landings decreased from 4.6% to

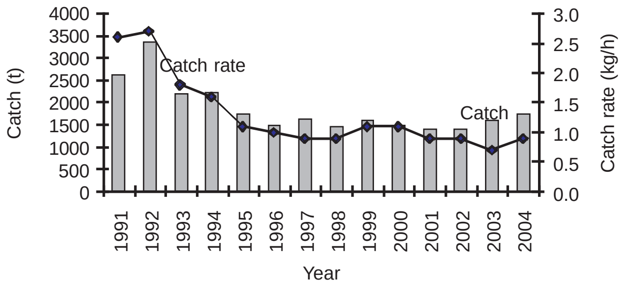

Fig. 1. Catch and catch rate of catfish landed by trawlers at New Ferry Wharf

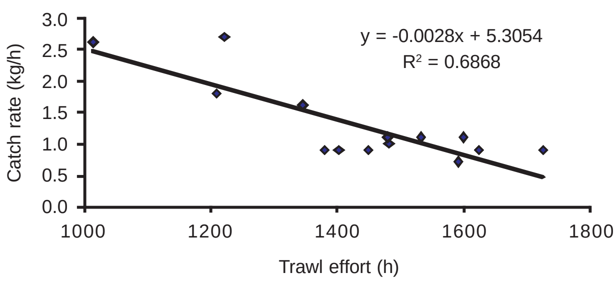

Fig. 2. Relationship between trawl effort and catch rate of catfish landed at New Ferry Wharf

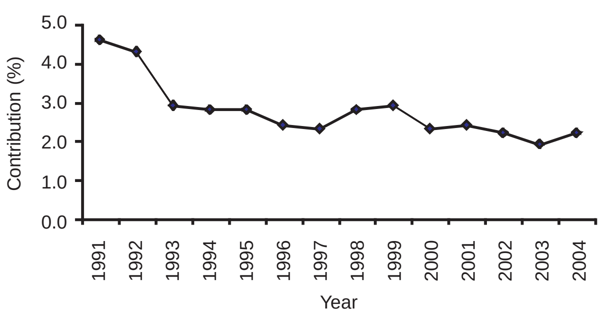

Fig. 3. Contribution of catfish to trawl landings at New Ferry Wharf

2.2% (Fig. 3), which shows that the landings of other resources in the trawl fishery did not decrease as that of the catfish. Due to ban on mechanized fishing during south-west monsoon, the trawl effort was less during June-August (Fig. 4). The catch rate was higher during August-October (1.5-1.7 kg/h) compared to November – July (0.8-1.3 kg/h).

Species composition

Analysis of species composition shows that the catfish fishery was supported by ten species of which *O. militaris* (29.4%) and *T. dussumieri* (34.2%) were dominant, together contributing 63.6% to the landings (Table 1). In addition to the eight species listed in Table 1, *T. maculatus* and *T. platystomus* were recorded, but rarely in the landings. To find out whether the decline in catfish fishery from 1995 was due to decline in the catch of any one species or a

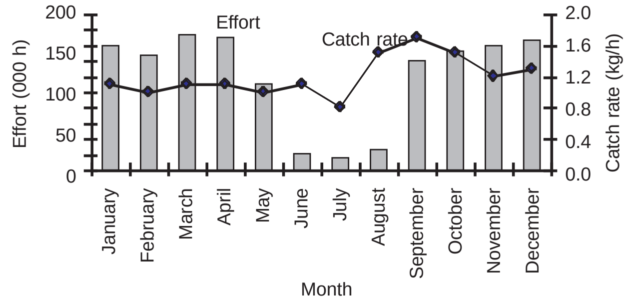

Fig. 4. Monthly average trawl effort and catch rate of catfish during 1991-2004

combination of several species, the catch by species and the contribution of each species to the catfish landings were estimated for the period 1991-2004. *T. tenuispinis*, which was landed in good quantities during 1991-1995 (annual average catch: 105 t; 4% of catfish landings) reduced drastically and totally disappeared from the catch from 2001.The landings of *T. serratus* also decreased substantially since 1995. The landings of two dominant species, *viz*., *T. dussumieri* and *O. militaris* also decreased since 1995, but their composition in the catfish catch did not decrease. *T. sona* is the only species that showed increase in the landings. Based on the catch and species composition, the susceptibility of the eight catfish species to the commercial fisheries could be serialized as follows (beginning from the most susceptible species): *T. tenuispinis*, *T. serratus*, *T. thalassinus*, *T. jella*, *T. caelatus*, *T. dussumieri*, *O. militaris* and *T. sona.*

Exploitation landmarks in the life of catfish

To find out the exploitation landmarks in the life of the catfish, the total length of 5,893; 2,186; 3,384 and 15,036 individuals of *T. thalassinus*, *T. jella*, *T. caelatus* and *O. militaris* respectively were measured. By applying the K and Lα values estimated for catfishes off Mumbai by Chakraborty *et al.* (1997) to the length-at-exploitation in the present study, the following exploitation landmarks in the life of catfish were identified (Fig. 5): (i) The minimum length-at-recruitment (L_r) differed only marginally between the species and ranged between 10 and 13 cm (age: 5-6 months). However, the L_r was only 11.8% of Lα for *T. thalassinus*, whereas it was 19.3 to 21.7% for the other species. (ii) The mean length of exploitation (L_{mean}: 27.5-30.0 cm) also differed only marginally between the species. However, the L_{mean} was only 33.0% of Lα for *T. thalassinus* compared with 45.8 to 54.8% for the other species. The mean age at exploitation was 17 months for *T. thalassinus* and only 12 months for *O. militaris*. (iii) *T. thalassinus* mature late at age 25 months compared to early maturity of 14 to16 months by the other three species. However, the length at first maturity (L_m) was only 43.8% of Lα for *T. thalassinus* whereas it was 51.3% to 55.0% for the other

Table 1. Species composition (%) in the catfish landings by the trawlers at New Ferry Wharf

Year	*Osteogeneiosus militaris*	*Tachysurus dussumieri*	*T. caelatus*	*T. sona*	*T. thalassinus*	*T. jella*	*T. tenuispinis*	*T. serratus*	Others*
1991	27.2	36.3	4.5	3.0	18.3	3.2	4.1	2.0	1.5
1992	24.0	35.5	5.9	3.9	19.1	2.6	5.7	2.5	0.8
1993	28.9	39.3	6.6	4.1	14.4	3.5	1.7	1.2	0.3
1994	29.0	30.5	11.3	6.9	12.5	4.4	3.3	1.1	1.0
1995	29.4	28.4	13.2	9.8	6.3	5.3	6.8	0.3	0.5
1996	28.7	37.7	12.6	8.6	4.5	5.3	1.8	0.3	0.5
1997	29.4	39.4	8.2	12.2	4.6	3.4	1.5	1.3	0.1
1998	31.9	27.3	14.1	16.6	5.0	4.5	0.2	0.2	0.2
1999	30.4	30.4	15.7	16.8	3.1	3.2	0.1	0.1	0.1
2000	25.6	28.1	13.6	13.8	15.6	3.0	0.1	0.1	0.1
2001	29.9	30.9	7.4	11.6	16.5	2.9	0.0	0.8	0.0
2002	32.5	32.7	11.7	15.0	3.3	3.4	0.0	0.8	0.5
2003	33.1	35.8	9.6	14.1	3.2	3.4	0.0	0.6	0.3
2004	33.1	35.9	9.5	14.1	3.2	3.4	0.0	0.6	0.3
Average	29.4	34.2	9.9	9.8	9.2	3.6	2.3	1.1	0.5

* *T. maculatus* and *T. platysomus*

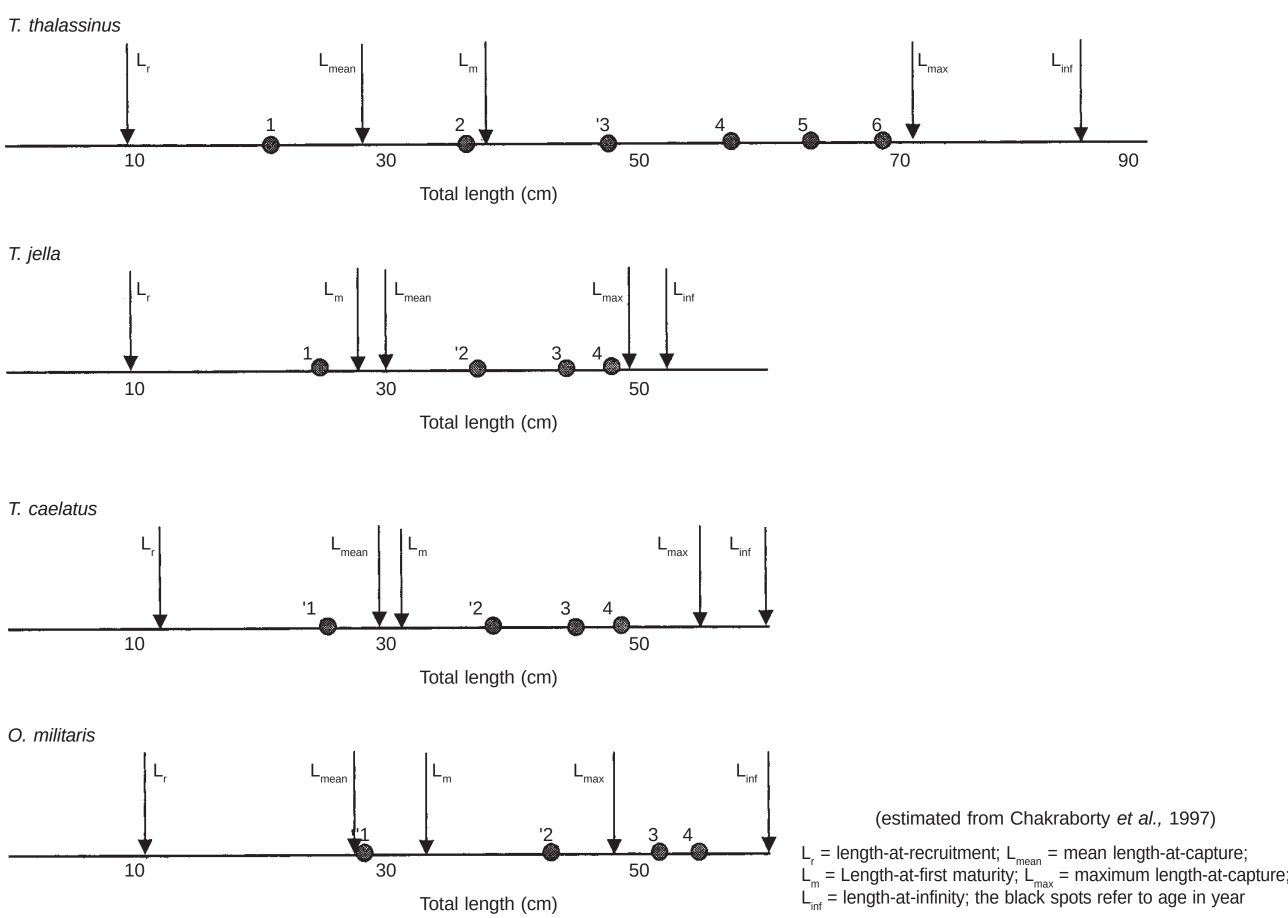

Fig. 5. Exploitation landmarks in the life history of catfish

three species. (iv) Except for *T. jella*, the L_{mean} was lower than L_m for other species, especially for *T. thalassinus*. *T. thalassinus* are exploited in large quantities, eight months before they attain first maturity. (v) *T. thalassinus* was the largest (Lα = 85 cm), but with very slow annual growth coefficient (K = 0.28). It is evident that compared to other species, *T. thalassinus* grow slowly in the first two years, attain large size (Fig. 6), mature late, get recruited early to the fishery and a large majority are exploited before attaining first maturity.

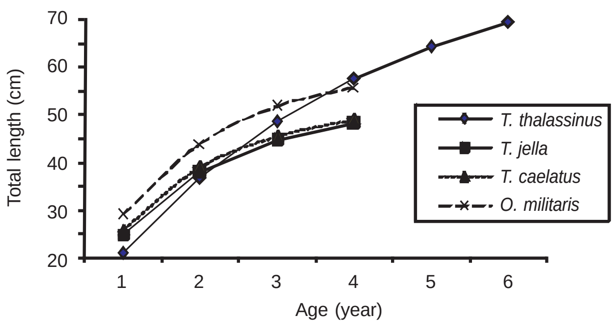

Fig. 6. Growth curve of catfish (estimated from Chakraborty *et al.*, 1997)

Sex ratio in relation to size groups

For the purpose of sex ratio studies, 193; 1,246; 787 and 262 specimens of *T. jella*, *O. militaris*, *T. caelatus*, *T. tenuispinis* and *T. thalassinus* were examined respectively. Analysis of sex ratio in different length groups revealed that males were dominant up to 30 cm total length in *T. jella*, *O. militaris* and *T. caelatus* and up to 50 cm length in *T. tenuispinis* and *T. thalassinus* (Fig.7). In the larger fish, the number of males substantially reduced and at lengths closer to L_{max}, males were rarely found. Males were not found at lengths larger than 43, 45, 49, 53 and 57 cm of *T. jella*, *O. militaris*, *T. caelatus*, *T. tenuispinis* and *T. thalassinus*, respectively.

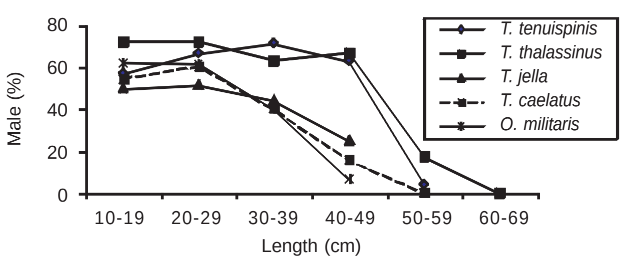

Fig. 7. Occurrence of male in different length groups; vertical lines are length-at-first oral incubation

Fecundity

The number of mature intra-ovarian eggs in females was considered for fecundity estimates. The number of mature ova in *T. caelatus* ranged from 44 to 81 (average: 63 eggs), *O. militaris* 27 to 61 (45), *T. thalassinus* 40 to 55 (47) and *T. tenuispinis* 72 to 89 (81) (Table 2).

The ova diameter frequency distribution in stage VI ovaries of four species is shown in Fig. 8. Three distinct groups of ova each with a mode are evident. All the ova between 11 mm and 17 mm (mode: 15 mm) in *T. tenuispinis*, 11 mm and 18 mm (mode: 14 mm) in *T. thalassinus*, 12 mm and 16 mm (mode: 15 mm) in *T. caelatus* and 10 mm and 15 mm in *O. militaris* (mode: 13 mm) were fully ripe, transparent and yellow. The ova were sharply separated in a single batch from the immature stock. The presence of maturing opaque and translucent ova of smaller size indicates that catfish is a fractional spawner.

Based on ova diameter frequency polygon, Dmitrenko (1970) reported that the entire spawning cycle of *A. thalassinus* lasts for about two months and breeding takes place once in a year in the vicinity of Kathiawar Peninsula of India. Dan (1977) and Mojumdar (1978) also made similar conclusions on *T. tenuispinis* and *T. thalassinus* off Visakhapatnam.

Oral incubation

Males with fertilized eggs in their oro-buccal cavity were noticed from 33 cm onwards in *T. jella*, 25 cm in *O. militaris*, 26 cm in *T. caelatus*, 42 cm in *T. thalassinus* and 44 cm in *T. tenuispinis*.

The number of eggs incubated in the oro-buccal cavity of males of *T. caelatus* and *O. militaris* were 54 and 56, respectively, which is less than the highest fecundity noticed in the respective ovaries (81 and 61). The highest fecundity

Table 2. Fecundity of catfish

Species	Sample size	Length range (cm)	Fecundity		Maximum number of eggs in oral cavity of males
			(range)	(average)	
T. caelatus	27	37-55	44-81	63	54
O. militaris	25	26-45	27-61	45	56
T. thalassinus	7	39-47	40-55	47	
T. tenuispinis	15	42-56	72-89	81	

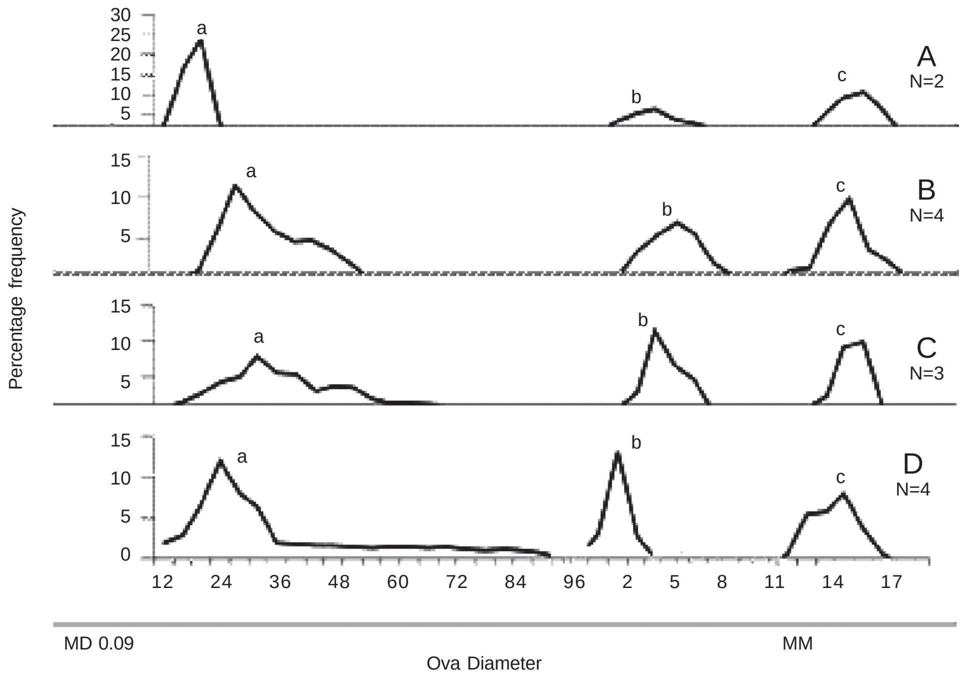

Fig. 8. Ova diameter frequency distribution of mature ovary (stage VI) of *T. tenuispinis* (A), *T. thalassinus* (B), *T. caelatus* (C) and *O. militaris* (D); N = number of sample ovary; mode a: opaque, immature ova; b: translucent, immature ova; c: ripe ova

reported by Muthiah and Rao (1985) was 207 eggs (average: 190 eggs) in *T. dussumieri*. They also observed that males could hold only 100 or a few more ripe eggs in the oro-buccal cavity.

A comparison of data on the fecundity and the number of eggs incubated gathered from earlier publications for six species of catfish also showed that the number of ripe eggs recorded in oro-buccal cavity of gestating males was less than the highest number of eggs noticed in the ovaries (Table 3). There are two possibilities for this mis-match. (i) Perhaps male does not incubate all the eggs released by the female. The males may be taking a limited number of eggs due to limitation in space in their oro-buccal cavity to accommodate all the eggs and the hatched-out larvae. The larvae remain in the parent's mouth until the whole yolk gets absorbed. This may be a strategy to ensure high hatching and survival rates. (ii) Another possibility is that the eggs under incubation may be ingested or spewed at the time of capture and struggle in the fishing gear.

Table 3. Comparison of fecundity and number of oral-incubated eggs in different species of catfish

Species	Location	Length (cm)	Fecundity	Eggs incubated	Reference
T. thalassinus	Visakhapatnam		25 - 42		Mojumdar, 1978
	Mandapam	38 - 42	31 - 61	27 - 40	Menon, 1979; 1984
	Mumbai	42 - 47	40 - 55		Present study
T. caelatus	Mandapam	35	30 - 70	37	Menon, 1979
	Mumbai	26	44 - 81	54	Present study
T. tenuispinis	Visakhapatnam	28	29 - 82	28	Dan, 1977
	Mumbai	50 - 53	72 - 89		Present study
T. platysomus	Mandapam	32	32 - 45	19	Menon, 1984
T. dussumieri	Mandapam	67 - 72	108 - 165	63	Menon, 1984
	Mangalore		170 - 207	100 - 102	Muthiah and Rao, 1985
O. militaris				15 - 20	Day, 1878
	Hooghly estuary		18 - 63		Pantulu, 1963
	Mandapam	31	30 - 71	62	Menon, 1984
	Mumbai	25 - 45	27 - 61	56	Present study

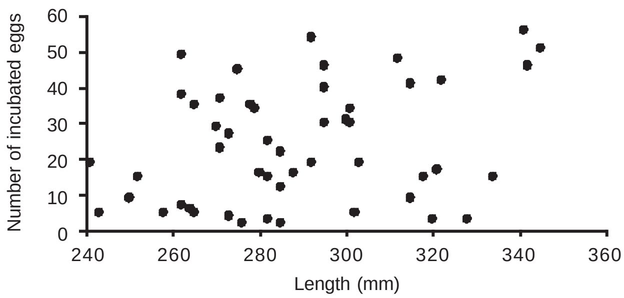

Fig. 9. *O. militaris* : relationship between total length and number of oral-incubated eggs

Fifty-one gestating males of *O. militaris* were used to find out relationship, if any, between the fish length (24 to 35 cm) and the number of eggs incubated (2 to 56 eggs). The result indicated a poor relationship (Fig. 9). Silas *et al.* (1980) also did not find any relationship between the length of *T. maculatus* and the number of eggs incubated. It appears that the incubating eggs observed in the oro-buccal cavity are only a partial quantum of eggs that would have been incubated by the male. There would have been a relationship between fish size and the number of eggs incubated, had all the ingested and spewed eggs been accounted. The observation in the present study of a number of fresh and intact eggs and larvae in the stomach of male *T. thalassinus* (total length: 43 – 50 cm) during September-October and December-January support this conclusion. Dan (1977) reported similar phenomenon in the male *T. tenuispinis*. It appears that the males can incubate only few eggs, and are forced to lose a portion of those eggs when encountered by the fishing gear.

To test whether the males starve during oral egg incubation, the stomach of 53 male parents of *O. militaris* and one male parent each of *T. tenuispinis* and *T. thalassinus* were examined. Except two individuals of *O.militaris*, all others had empty stomach. Chidambaram (1941) observed that the male parent of *Arius jella* starves during oral gestation until the yolk sac of embryo is absorbed. James *et al.* (1989), while studying the flesh-bone ratio of gestating males noticed reduction in weight and concluded that starvation for about two months during gestating period reduced the weight. Dan (1977) also analysed sex ratio by length for *T. tenuispinis* and noticed decline of males in larger length groups and concluded possible oral gestation mortality among adult males. In the present observation, adult males at higher length groups in all species were found to be absent probably due to oral-gestation mortality. The starving, incubating male parent is likely to be vulnerable to fishing. This is evident from the occurrence of a large number of incubating males immediately after the cut-off length of oral incubation. Segregating the male *O. militaris* into smaller (2 cm) length groups, it was found that the

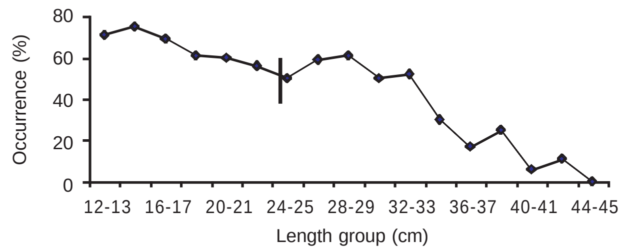

Fig. 10. *O. militaris* : occurence of male in different length groups; vertical line is length-at-first oral incubation

proportion of male in the catch abruptly increased after the cut-off length of oral incubation (25 cm) from 54% to >60% up to 29 cm, but the proportion decreased thereafter and there was no male beyond 43 cm (Fig. 10).

These observations indicate that in combination with low fecundity, the destruction of large number of eggs along with the male parent due to fishing, is seriously affecting recruitment. Moreover, the disappearance of larger males from the population is hastened by fishing. The bias in the sex ratio of younger fish towards male is probably to compensate for the loss of larger males later in the incubating age. However, this biological advantage is perhaps offset by higher fishing mortality of incubating males. In short, the supposedly advantageous strategy adopted by the catfish for protecting the eggs and larvae is no more relevant in this present period of intense fishing, and has become counterproductive for sustaining the population.

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